Extended Maxillary Sinus Augmentation to the Apical Area of the Neighboring Teeth: Advantages and Limitations

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The extension of sinus floor augmentation beyond the edentulous area, apical to the adjacent teeth, has many therapeutic advantages, but the reliability and safety of the procedure has not been assessed in depth. The present study compares the gain of bone anterior and posterior to the edentulous area and evaluates potential advantages and limitations in the clinical setting. The maximum vertical bone height in the edentulous and extended maxillary sinus augmentation (EMSA) areas and the thickness of the sinus membrane of 65 patients were measured. Those measurements were analyzed using the t test and Pearson correlations. The average vertical bone gain was 11.98 ± 3.53 mm in the edentulous sinus area and 8.60 ± 3.89 mm in the EMSA area (P < .05). Minor perforations of the sinus membrane occurred in 4 patients. There were no postsurgical graft contaminations or periradicular changes during follow-up. EMSA is a reliable and safe procedure with a very low complication rate. This approach is effective and safe for patients who have lost part of their posterior dentition. It enables future implant placement while avoiding the need for sinus reentry and proximal teeth extraction. Int J Periodontics Restorative Dent 2018;38:451–456. doi: 10.11607/prd.3454

Maxillary sinus augmentation is a predictable and reliable approach for correcting bone deficiencies in the posterior maxilla that are due to periodontal disease, endodontic infection, and sinus pneumatization.1 The lateral window approach2-5 has been demonstrated to be reliable, with high success and low complication rates.6 However, there are several complications that may compromise the outcomes of sinus floor augmentation.7,8 The most common intraoperative complication is sinus membrane perforation, with a reported incidence of up to 59.8%.9 Wound infection, abscess, or dehiscence with drainage and maxillary sinusitis are the most frequent postoperative complications. Extraction of teeth adjacent to a previously augmented sinus floor requires reentry of the sinus, which is a complex procedure with a low success rate due to structural changes in the sinus membrane.10 A segmental treatment in which all teeth in the posterior segment are extracted allows easier surgical access and a predictable treatment plan while avoiding the need for re-entry, but this alternative leads to early extraction of functional teeth. An alternative treatment approach in which neighboring teeth are preserved while the need for future sinus reentry is prevented could therefore be highly valuable.
This study aimed, for what the authors believe to be the first time, to describe sinus floor augmentation extended mesially and distally beyond the boundaries of the edentulous ridge to include the sinus area apical to these structures. To the best of the authors’ knowledge, there are no reports describing the limitations, safety, and possible complications of this procedure. The objective of the study was to evaluate the outcomes and complication rate of extended maxillary sinus augmentation (EMSA) in a relatively large group of patients.

Materials and Methods

The study was approved by the institutional ethical committee of Tel-Aviv University. Patient records of sinus augmentation procedures performed from 2011 to 2014 retrieved from the university dental clinic and those of a private practice were screened by two observers. The inclusion criteria were provision of signed informed consent, good health (American Society of Anesthesiologists score of 1 to 2), controlled periodontal status, partial edentulism in the posterior maxilla, a prosthetic treatment plan consisting of placement of one to three implants in the premolar and molar region of the maxilla, and requiring a lateral access sinus floor augmentation procedure, the presence of teeth adjacent to the edentulous area, and teeth in the EMSA area that were vital or endodontically treated. Only cases with full radiographic and clinical evaluations (ie, preoperative and 4 to 6 months postoperative computerized tomographic [CT] scans and 12 months postoperative panoramic radiographs) were included. The exclusion criteria were a history of sinus pathology, periapical pathosis, and large septa in close proximity to the dentate area. Root apices projecting into the sinus floor were also a limiting factor for EMSA.

Description of the Surgical Procedure

Surgery was performed under local anesthesia according to the technique described by Boyne and James. A full-thickness access flap was prepared with midcrestal and vertical releasing incisions. A lateral window was created using a low-speed headpiece cooled by sterile physiologic saline. The access window was extended laterally and apically approximately 3 mm from the apex of the adjacent teeth. The sinus membrane was raised in the extended areas, and a particulate bone graft was placed underneath. In the present study, a combination of approximately 0.5 g deproteinized bovine bone mineral (DBBM, Bio-Oss, Geistlich) and 2.5 mL particulate mineralized bone allograft (MinerOss, BioHorizons) was applied using a bilayering technique in 42 (65%) of the patients. DBBM was placed close to the sinus membrane, while the particulate mineralized bone allograft filled the remaining sinus cavity. In the remaining 23 (35%) cases, approximately 2 g DBBM served as the sole filler material. The access window was covered with a resorbable collagen membrane.

A periosteal incision was made, and the soft tissues were approximated and sutured with horizontal mattress and single interrupted sutures (4-0 Vicryl Rapide, Ethicon). Postoperative instructions included rinsing with 0.2% chlorhexidine solution twice daily for 2 weeks, and antibiotics were prescribed for 10 days (Augmentin 875 mg, GlaxoSmithKline). Patients who were allergic to penicillin received Dalacin-C 150 mg qid (Pfizer). Analgesics were provided only when needed.

Radiographic Evaluations

CT scans were taken preoperatively and 4 to 6 months postoperatively, and follow-up panoramic x-rays were taken 1 year postoperatively. Three measurements 2 mm apart were taken of the maximum vertical bone height in the edentulous area and in the EMSA. The sinus and periapical areas of the adjacent teeth were evaluated using a panoramic x-ray taken 1 year posttreatment.

Clinical Evaluations

Data on intraoperative (mainly sinus membrane perforations) and postoperative complications (wound infection, abscess, or dehiscence with drainage and maxillary sinusitis) were recorded, as were postoperative endodontic and periodontal evaluations of the neighboring teeth in the extended area.
**Statistical Analysis**

Statistical analysis was performed using the statistical package SPSS for Windows version 19.0 (Microsoft). Descriptive statistics included frequency values (absolute and relative values) and metric data (arithmetic mean, standard deviation, and median). The t test was applied for evaluation of vertical bone gain in the premolar vs molar areas, vertical bone gains in the edentulous sinus vs the extended areas, and single vs multiple tooth augmentation. Pearson correlations were used to test associations between age and bone measurements. The statistical significance was defined as \( P < .05 \).

**Results**

A total of 400 patients underwent sinus augmentation procedures during the study period, and 65 of them met the inclusion criteria. The sample was composed of 37 women and 28 men, with a mean age of 57.25 ± 9.22 years (range: 37 to 75 years). EMSA was performed beyond the edentulous area apically to the following:

- Periodontally hopeless teeth that were temporarily retained for various reasons and planned for future extraction (14%)
- Endodontically treated teeth with healthy or reduced periodontal support (19%) (Fig 1)
- Restored teeth with normal periodontal support (24%)
- Teeth with reduced periodontal support and normal mobility (43%) (Fig 2)

**Surgical Outcome**

The average vertical bone gain was 11.98 ± 3.53 mm in the edentulous sinus area and 8.60 ± 3.89 mm in the EMSA area (\( P < .05 \)). Preoperative and postoperative bone height and bone gain in the edentulous and extended areas are summarized in Table 1. Preoperative bone height was significantly higher in the extended area than in the edentulous area; however, differences
between groups at the postoperative evaluation were not significant. Average vertical bone gain was significantly higher in the edentulous area compared to the extended area (P < .001). Vertical bone gain at the premolar and molar areas in the edentulous and the extended sinus augmentation regions are summarized in Table 2. While the average vertical bone gain in the edentulous area was significantly lower for single-tooth procedures compared to multiple-teeth interventions (P < .023), only a similar trend that did not reach a level of significance was found in the extended area.

Complications

Minor perforations (< 5 mm) of the sinus membrane occurred in four cases and were successfully treated with a resorbable collagen membrane.11 Perforations did not influence the outcome of the procedure. There was no case of intraoperative abnormal bleeding that prevented finalizing the procedure. No postsurgical graft contamination was recorded.

Effect on Neighboring Teeth

No periradicular changes were evident in the 1-year follow-up panoramic x-rays.

Discussion

A treatment approach for lateral maxillary sinus augmentation that extends apic ally to the neighboring teeth has not previously been described. EMSA is a modular treatment modality that supports the strategy of maintaining compromised teeth. This technique may allow future implant placement while avoiding the need for sinus reentry. Although the average vertical bone gain was lower in the extended area compared to the edentulous area, the preoperative bone height was significantly higher in the extended area, yielding a postoperative vertical height that was similar in both areas. It appears that a similar vertical bone height in all augmented areas may be expected following the EMSA approach.

The differences in preoperative bone height and vertical bone gain between the premolar and molar areas in primary and extended sinus augmentations were not significant. This is in contrast to a
previous report in which greater new bone formation was found in the premolar region compared to the molar region. Reduced vertical bone gain may be expected in sinus floor augmentation of single tooth areas, probably due to restricted access and limited membrane elevation ability. Moreover, sinus floor augmentation in a single tooth area has a higher rate of sinus membrane intraoperative perforations, while an extended sinus procedure with a wider window may allow better surgical access.

Perforation of the sinus membrane occurred in only 4 of the 65 (6.1%) sinus augmentation procedures, in agreement with the findings of Schwarz et al. The presence of Underwood septa or projecting roots were a limiting factor in performing the EMSA procedure. EMSA did not lead to postoperative contamination or suppuration of the grafted sinuses, as Zijderveld et al also reported.

Extension of the sinus floor augmentation apically to neighboring teeth did not increase the number of intraoperative or postoperative complications. Apical periodontitis, dental abscesses, implant treatment, teeth extraction, and periodontal disease may frequently lead to odontogenic sinusitis, which accounts for approximately 10% to 12% of cases of maxillary sinusitis. In spite of the proximity to endodontically treated and periodontally involved teeth, no sinus pathology was clinically or radiographically diagnosed at follow-up among the patient cohort. Although the diagnostic value of panoramic x-ray is limited, the authors felt there was no medical justification for a third CT scan at the 1-year follow-up evaluation.

Teeth in the extended area had a certain degree of periodontal involvement in 65% of the cases. However, only 14% of those were hopeless teeth maintained for prosthetic reasons. All patients presented controlled periodontal status and underwent routine periodontal care to reduce the overall bacterial load and the risk for contamination of the grafted sinus.

Teeth with severe loss of periodontal support can be retained and kept healthy with a strict program of periodontal therapy and supportive periodontal care. The clinical decision to retain severely compromised teeth is based on complex considerations. Oral implant survival after 10 years of service does not surpass that of compromised but successfully treated natural teeth, emphasizing the advantage of EMSA in enabling the maintenance of neighboring teeth and the possibility of replacing them with implants in cases of future extraction. None of the patients had dental complications in their neighboring teeth, and there were no cases of irreversible pulpitis or radiographic signs of periapical pathosis apically to the neighboring teeth in the extended area. Pulp necrosis associated with elevation of the sinus membrane over the apices of vital teeth in close proximity to the sinus floor has been recently suggested. However, periapical tissues will not be harmed as long as the integrity of the alveolar bone around the apexes of the roots remains intact.

None of the apical areas of the teeth in the extending area were projecting into the sinus, and all of the treated teeth were surrounded by alveolar bone proper. During the lateral window preparation, special care was taken to avoid interference with the blood supply to the apices of the vital teeth roots. A safety zone of bone beyond the apical area of those teeth roots was kept. The superior dental plexus, innervating the upper teeth, is located in the thick alveolar process of the maxilla, which remains intact during the lateral window opening, and not on the maxillary sinus wall. While none of the involved vital neighboring teeth developed pulp necrosis as a result of the procedure, additional larger studies are warranted to determine the actual risk of its occurrence. It is therefore advisable to include a pulp vitality evaluation as part of the routine follow-up for this type of procedure.

Of the included patients, 12 (19%) had endodontically treated teeth. A recent clinical report suggested a possible serious adverse event of implant-associated vertical root fracture (VRF) in adjacent endodontically treated teeth. When a VRF is diagnosed, it is usually necessary to extract the involved tooth. However, a VRF is often identified only after all surgical and restorative procedures have been completed, emphasizing the importance of carrying out EMSA to endodontically treated teeth during sinus augmentation. Doing so may avoid the need for additional surgical augmentation in cases of cracked neighboring teeth due to VRF.
Conclusions

The results of the present study revealed that laterally performed EMSA that also includes the apical area of neighboring compromised teeth may be considered for patients who have lost part of their posterior dentition. This approach may allow future implant placement following the extraction of neighboring teeth, while avoiding the need for sinus reentry. Finally, the EMSA approach carries minimal risk of complications and side effects.

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References